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The Belt and Road Initiative's effect on supply-chain trade: evidence from structural gravity equations

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This article considers the effect of China's Belt and Road Initiative on supply-chain trade for 64 economies in the period 2002–2011. We employ a structural gravity equation to estimate the impact of trade-cost reducing measures—notably infrastructural improvements and the creation of free trade agreements—on supply-chain trade and welfare in general equilibrium. We find that infrastructural investments will yield asymmetric benefits to China, Russia and Southeast Asian countries stemming from greater European market access. Our results also suggest that China's alternatives to foster (inter)regional economic growth through the Regional Comprehensive Economic Partnership and the Trans-Pacific Partnership offer much less attractive economic prospects.

Keywords: China, Belt and Road Initiative, free trade agreements, infrastructure, gravity model, trade predictions
JEL Classifications: F13, F14, F15, F17

Introduction

In 2013, the People's Republic of China (PRC) launched an ambitious project now known as the Belt and Road Initiative (BRI). Being President Xi's signature foreign policy, its purpose is to establish modern trade routes spanning from China throughout Eurasia and the Indian Ocean akin to the ancient Silk Road.

From an economic perspective, the BRI is grounded in China's central role in the world's economy as assembler-producer of manufactured goods. Combined with its domestic overcapacity, China seeks to use the BRI to provide both the labour and capital required to construct the necessary infrastructure, such as high-speed railroads, harbours, and oil and gas (Chen, 2018, 44–45). The BRI is envisioned to stimulate economic cooperation, foreign direct investment (FDI) and international trade among all the participating countries.

A key question is if, and by how much, BRI's tentative infrastructural developments and trade policies will affect the world economy in light of alternatives, such as the Regional Comprehensive Economic Partnership (RCEP) and the Trans-Pacific Partnership (TPP). Therefore, the purpose of this article is to provide a quantitative assessment of the BRI's effects on global trade—particularly for China, the European Union (EU), Russia and Asian countries that the PRC views as countries central to the BRI's success.

To the best of our knowledge, only a few articles have studied BRI's effect on international trade. These articles rely on the gravity equation of international trade to measure the impact of particular BRI-inspired free trade agreements (FTAs) on gross trade flows for China and a limited number of partner countries in partial equilibrium. This article seeks to make at least two contributions.

First, we employ a state-of-the-art structural gravity equation *à la* Yotov et al. (2016) and Anderson et al. (2018), to calculate the trade and welfare effects of BRI on a large number of countries in *general* equilibrium. In doing so, we acknowledge that BRI will change trade costs not only for countries directly involved in BRI (that is, partial equilibrium), but that this will also indirectly alter relative trade costs and trade vis-à-vis excluded countries. Our general equilibrium results fully incorporate all direct and indirect effects of our counterfactual trade policy shocks on trade costs, production and trade, which paints a more complete and theory-consistent picture of BRI's economic impact on the world economy.

Second, this article is the first to estimate BRI's effects on trade in global value chains, rather than gross exports. By now, a large literature has documented the drawbacks of using gross trade flows to understand the structure of the world economy in, which production is globally fragmented (for example, Johnson and Noguera, 2012; Koopman et al., 2014; Timmer et al., 2014). That is, conventional trade statistics relay the total value of internationally traded intermediate goods and not only the economic value that was added in the most recent stage of the production (or assembly) process. The literature has shown that analyses based on gross trade data yield severely biased results that do not properly account for backward and forward linkages in China's global value chains. To shed more light on the consequences of BRI for modern international trade, we therefore draw on the OECD's Trade in Value-Added (TiVA) dataset and the World Input-Output Database for measures of supply-chain trade. In particular, we compare and contrast our outcomes in terms of different measures of value-added exports recently proposed by Los and Timmer (2018).

Empirically, we will examine how trade costs affect general equilibrium outcomes for a number of scenarios. These scenarios will all account for different ways in which the BRI could reduce trade costs in (i) the high-speed railway connecting China to Singapore through Laos, Thailand and Malaysia, and (ii) the railway connecting western China with Europe via Kazakstan, Russia and Belarus into Poland.[1] Specifically, we will examine how BRI will affect trade outcomes when trade costs are reduced by means of infrastructural developments leading to a decrease in the geographic distance between countries' economic centres. Alternatively, we will examine how the elimination of trade frictions such as tariffs through the creation of FTAs might be a relevant complement—or alternative—to BRI. In our analysis, we will demonstrate the relative importance of both channels and their effect on global supply-chain trade and welfare.

The structure of this article is as follows. The next section introduces the related literature on the role of infrastructure and FTAs on international trade, in particular, in the context of Asian regional integration. We then discuss the methodology and data, followed by a presentation of the empirical findings. The final section discusses the main results and concludes.

Literature

In studies of international trade, the gravity equation is the workhorse theoretical and empirical model that can be readily used to estimate how trade costs affect international trade flows between exporters and importers (for surveys of this extensive literature, see van Bergeijk and Brakman, 2010; Head and Mayer, 2014). In its simplest form, the gravity equation predicts that bilateral trade between countries increases with the exporter's and importer's economic size, and decreases with their trade costs. From an international trade perspective, the BRI essentially is an exercise aimed at reducing the trade costs between China and its partner countries.

By now, there is a vast gravity-inspired literature on the determinants of trade costs and their effect on international trade (see, in particular, Anderson and van Wincoop, 2004; McCallum, 1995; Novy, 2013). For the purposes of this article, this discussion of the literature shall focus on geography and institutions—in particular trade policy—as the determinants of interest.

Geography is one of the main sources of trade costs, that is, countries' spatial characteristics affecting their domestic and international transportation costs. The characteristics usually considered in the literature include geographic distance, whether countries share a common border and if they are either landlocked or island states.

Intuitively, a greater geographic distance, not sharing a common border and/or being more remote from a trade partner negatively affects transportation costs and therefore international trade. These consequences can be mitigated through infrastructural developments, such as the creation of highways, tunnels, airports and harbours.

Indeed, infrastructure is an important determinant of transportation costs (for an overview, see Hummels, 2007). For example, Limao and Venables (2001) find that poor infrastructure accounts for around 40% of coastal countries' trade costs; this share can be as high as 60% if trade partners are landlocked.

A number of detailed studies provide insightful examples of how changes in infrastructure alter bilateral trade costs and international trade. Pascali (2017) finds that the introduction of the steamship in the first wave of globalisation changed the bilateral trade costs for certain exporter-importer pairs relative, making it possible not only to increase trade, but also to establish new trade routes independent of maritime winds. In a related vein, Donaldson (2018) shows how the development of railways throughout colonial India increased both intra-national and international trade and welfare. In contrast to infrastructural developments, the (temporary) removal of infrastructure negatively impacts trade and welfare, as illustrated by the closure of the Suez Canal in the 1970s (Feyrer, 2009). The literature also shows that not only the quantity of infrastructural connections, but also the quality of infrastructure is relevant for trade (Bougheas et al., 1999; Feyrer, 2018; Nordås and Piermartini, 2004).[2]

Trade costs and trade are also affected by institutions in their broadest sense. On the one hand, examples of persistent, time-invariant institutions shaping trade costs include cultural familiarity—for instance, in terms of a shared spoken language—and similar administrative and legal practises stemming from a shared colonial history (Head et al., 2010; Ku and Zussman, 2010). Institutional quality, such as the rule of law, also hampers trade in that it restricts exporters' market access to developing countries (Francois and Manchin, 2013).

On the other hand, trade costs are also affected by time-varying institutions shaped by trade policies. The most common examples include countries' membership of the World Trade Organisation (WTO) and FTAs (see, for example, Baier and Bergstrand, 2007; Kohl, 2014, 2017; Rose, 2004).

Specifically in terms of FTAs, there are two initiatives that are of particular interest to the PRC: (i) the Trans-Pacific Partnership (TPP), and (ii) the Regional Comprehensive Economic Partnership (RCEP) among participants of the Association of Southeast Asian Nations (ASEAN). There is also perhaps a third option, which would be to pursue signing a FTA with BRI-related countries rather than opting for the currently envisioned alternative of infrastructural development.

To facilitate the remainder of this discussion, it is useful to provide a brief overview of China's current FTAs and the available options. Table 1 lists the FTAs that the PRC has recently announced or that it has already enforced.[3]

First is the TPP, now officially known as the Comprehensive and Progressive Agreement for Trans-Pacific Partnership (CPATPP). Initially launched as a US-based mode of governance thought of as a means for the USA to increase its economic dominance in the Asian-Pacific, the explicit exclusion of China (and India) was intended to set a new level of standards for the international trade system which would be very difficult, if not costly, for China to adhere to. However, after the United States' withdrawal under President Trump, TPP gives a new and interesting platform for the PRC to consider joining, as it would yield market access to countries with which it does not yet have an FTA—specifically Canada and Japan.

However, RCEP offers an ASEAN-led alternative to TPP that *does* include China and India, along with the other four countries which have bilateral FTAs with the ASEAN group, that is Australia, Japan, New Zealand and South Korea. The agreement has not yet been concluded.

Devadason (2014) analyses the potential for Chinese export expansion under TPP and under ASEAN-based alternatives (ASEAN, ASEAN+3 and ASEAN+6, the latter being the same set of countries as RCEP).[4] Using a gravity equation with gross trade flows, she calculated the partial equilibrium effects of different FTA's representing TPP and ASEAN alternatives. Her results suggest that TPP would offer greater market potential to China than the ASEAN-based regional alternatives. However, given the unlikely outcome that China and the USA would converge on international product and investment standards under TPP, the author concluded that RCEP would be a more viable FTA for China to join in the short term whilst maintaining an open dialogue to consider joining TPP in the future.[5] However, to the best of our knowledge, subsequent research has been conducted to consider either FTA option's impact on supply-chain trade.

As for the BRI's outcome on trade, the only relevant study seems to be recent work by Herrero and Xu (2017). Theirs is an interesting approach in which they develop new proxies for geographic distance from China to the rest of the world, depending on whether trade occurs by means of air, land or maritime-based transportation. Based on their partial equilibrium elasticities of gross trade to these different measures of distance, they then calculate the implied effects on trade, assuming that BRI reduces land-based distance relatively more than maritime-based trade.[6]

The authors then consider the gains of implementing infrastructural BRI improvements without an underlying FTA, the gains of only having an FTA without a physical BRI, and a combination of both. Their results suggest that a reduction of travel time will mostly favour EU countries by 8–10%. The addition of an FTA would slightly reduce the EU's gains from BRI. The combination of both transport improvements and an FTA would yield largest gain to Russia (11%), followed by Albania (10%), and Germany, Hungary and Slovakia (~9%). Unfortunately, the reported estimates are not sufficiently detailed at the country level to facilitate a full comparison between all alternatives for all countries involved in TPP, RCEP and/or the BRI—not even for China.

Notwithstanding the insights obtained from previous gravity-based studies on TPP, RCEP and BRI, ours is essentially different in at least two important ways.

The first distinctive feature is that our analysis acknowledges the fact that modern-day globalisation is characterised by trade in value-added, rather than trade in final goods (see, for example Johnson, 2014; Johnson and Noguera, 2012; Timmer et al., 2013, 2014, 2015). By now, there also is a growing

Table 1. *China's FTAs.*

Partner	Bilateral	APTA	ASEAN	RCEP	TPP
APTA	*				
ASEAN	*				
Australia	*			*	*
Bangladesh		*			
Brunei			*	*	*
Cambodia			*	*	
Canada					*
Chile	*				*
Costa Rica	*				
EU					
Georgia	*				
Hong Kong	*				
Iceland	*				
India		*		*	
Indonesia			*	*	
Japan				*	*
Laos		*	*	*	
Macao	*				
Malaysia			*	*	*
Maldives	**				
Mexico					*
Moldova	**				
Myanmar			*	*	
New Zealand	*			*	*
Norway	**				
Pakistan	*				
Peru	*				*
Philippines			*	*	
Russia					
Singapore	*		*	*	*
South Korea	*	*		*	
Sri Lanka		*			
Switzerland	*				
Taiwan	*				
Thailand			*	*	
United States					†
Vietnam			*	*	*

Note: * (**) indicates an enforced (announced) FTA; † indicates a country's withdrawal from a given FTA. China has bilateral agreements with APTA (Asian-Pacific Trade Association), ASEAN (Association of South East Asian Nations), is member of RCEP (Regional Comprehensive Economic Partnership) and considers joining TPP (Trans Pacific Partnership).
Source: http://fta.mofcom.gov.cn/english/fta_qianshu.shtml and http://rtais.wto.org/UI/PublicSearchByMemberResult.aspx?MemberCode=156&lang=1&redirect=1 [accessed 22 May 2018].

literature in which value-added trade flows are incorporated into gravity-based analyses (Aichele and Heiland, 2018; Brakman et al., 2018; Caliendo and Parro, 2015; Johnson and Noguera, 2017; Kaplan et al., 2018; Noguera, 2012).We add to this approach an application of counterfactual policy analysis in the context of the BRI. We therefore employ data on value-added exports—rather than traditional measures of gross exports—to correctly measure international supply-chain trade as our dependent variable.[7] This decision is further motivated by China's central role as one of the world's major assemblers in global value chains.

The second distinguishing feature of our analysis is that we rely on a novel, state-of-the-art structural gravity model that allows for the calculation of trade outcomes under specific trade policy scenarios (for an in-depth discussion of this literature and available methods, see Costinot and Rodríguez-Clare, 2014). In particular, recent work by Yotov et al. (2016), and Anderson et al. (2018) enables researchers and policy makers to determine partial and general equilibrium changes to trade and welfare for a variety of trade policy changes, including the removal of borders, the introduction/removal of FTAs, and modifications to non-tariff barriers. While previous research on BRI presents the trade cost elasticities of China's FTAs in general, none of these articles explore different trade policy scenarios related to BRI and what their implied effects would be for international trade (in valued-added) and welfare in general equilibrium.

The added value of our approach—closely following Yotov et al. (2016) and Anderson et al. (2018)—is that we compute the general equilibrium effects on trade in value-added and welfare, given a simulated change in trade policy, and how it affects the country pairs involved directly and indirectly. The direct effect pertains to countries that, say, have signed on to the BRI by signing an FTA with China. Indirect effects are accounted for by means of the so-called multilateral resistance terms (MRTs), that is, price indexes that control for the fact that trade policies change trade costs between countries directly involved in the policy, but also relatively vis-à-vis all other countries in the world economy (Anderson and Wincoop, 2003; Feenstra, 2016). Our results shed further light on the economic outcomes of China's bold initiatives to shape the world economy in the 21st century.

Methodology and data

In gravity models, the standard interpretation of geographic distance is that it serves as a proxy for transportation costs—including shipping costs and the time investment required to ship goods from the origin to the destination. In the context of the present article, we assume that BRI's investments in infrastructure will reduce transportation costs and therefore increase international trade—both for countries directly involved with the policy as well as for countries indirectly affected through changes in their multilateral resistance terms (MRTs).

Alternatively, BRI sets out to reduce trade costs through the creation of FTAs. In their simplest form, FTAs reduce tariffs. However, more recent FTAs tend to be much more extensive by design, covering a wide variety of policy domains unrelated to tariffs, which may still serve as impediments to trade (Baier et al., 2018; Kohl et al., 2016). Examples of such policies include mutual recognition of product standards or even complete harmonisation of legislation.

Taken together, the key mechanisms through which we expect BRI to bring about a change in international trade is through either a change in geographic distance as a proxy for infrastructural investments, or the creation of FTAs as a substitute for such infrastructural developments.

Estimation with counterfactual scenarios

The computation of our counterfactual scenarios follows Anderson et al. (2018) and is described in the following steps (for the most detailed account of the procedure outlined below, see Yotov et al., 2016):

Step 1 is to estimate a baseline gravity equation,

$$X_{odt} = \exp[\beta_1 \ln\mathrm{DIST}_{od} + \beta_2 \mathrm{CNTG}_{od} + \beta_3 \mathrm{BRDR}_{od} + \beta_4 \mathrm{FTA}_{odt} + \delta_{ot} + \gamma_{dt} + \zeta_{od}] \times \varepsilon_{odt}, \quad (1)$$

where X is the bilateral trade flow between origin o and destination d in year t, lnDIST is the log geographical distance between the pair of countries, CNTG is a binary variable controlling for whether or not countries in a dyad are contiguous, BRDR equals 1 if trade has to cross an international border and is 0 if trade is intra-national, and FTA is 1 if a country-pair has an FTA in a given year and is 0 otherwise. The origin-year fixed effect δ_{ot} and destination fixed effect γ_{dt} enable us to control for outputs, expenditures and multilateral resistance terms in the context of the structural gravity equation, while the country-pair fixed effect ζ_{od} controls for time-invariant, pair-specific characteristics that are both observable (that is distance, common language, contiguity) and unobservables (aspects of trade policy) that may give rise to endogeneity bias (Baier and Bergstrand, 2007).[8]

Step 2 is to calculate the trade costs and trade cost elasticities with respect to our key policy variables of interest, that is geographic distance and FTAs,

$$(\hat{t}_{od}^{\mathrm{BSL}})^{(1-\sigma)} = \exp[\hat{\eta}_1 \ln\mathrm{DIST}_{od} + \hat{\eta}_2 \mathrm{CNTG}_{od} + \hat{\eta}_3 \mathrm{BRDR}_{od} + \hat{\eta}_4 \mathrm{FTA}_{odt}], \quad (2)$$

where $\sigma > 1$ is the elasticity of substitution among varieties, assumed to be constant across all baseline and counterfactual scenarios. $\hat{t}_{od}^{\mathrm{BSL}}$ indicates the estimated baseline (BSL) trade costs for country-pair od.

Step 3 is the actual implementation of the counterfactual trade policy scenario, in which we change geographic distance for a set of countries and/or introduce an FTA.[9] For infrastructural investments, we will provide estimates for three different degrees of improvement in transport costs. The ambitious, upper-bound case assumes that a 50% reduction in transport costs can be realised through BRI's investments in infrastructure. Our motivation for this upper-bound estimate is Herrero and Xu's (2017, 50) report that travel time on the Chonqing-Duisberg line had been cut by half. However, the same authors also provide another example where travel time decreased from 17–18 days to 12–13 days, that is a reduction of 30%. Finally, we assume that the lower-bound impact of BRI on transport cost reduction is 15%. So, in sum, we will analyse BRI's infrastructure improvements in terms of them leading to a 15%, 30% or 50% reduction in geographic distance.[10] For FTAs, the procedure is slightly less involved. In this case, we simply switch the FTA dummy-variable "on" for country-pairs that do not have an FTA in a given year, that is change the relevant FTA observations from 0 to 1.

Step 4 is to calculate the counterfactual (CFL) trade costs, given the implemented change in geographic distance and/or FTAs in Step 3,

$$(\hat{t}_{od}^{\mathrm{CFL}})^{(1-\sigma)} = \exp[\hat{\eta}_1 \ln\mathrm{DIST}_{od}^{\mathrm{CFL}} + \hat{\eta}_2 \mathrm{CNTG}_{od} + \hat{\eta}_3 \mathrm{BRDR}_{od} + \hat{\eta}_4 \mathrm{FTA}_{od}^{\mathrm{CFL}}]. \quad (3)$$

Step 5 is to solve the model so that it will yield either partial equilibrium, conditional general equilibrium or full endowment general equilibrium results, and to calculate their change with respect the baseline estimates. Essentially, one takes the counterfactual trade costs from Step 4 and predicts the counterfactual trade flows for the given level of output, expenditure and multilateral resistance terms, which yields outcomes in partial equilibrium. Note that partial equilibrium does not allow for MRTs to change, so indirect effects on countries not immediately involved in the counterfactual scenario will not be considered to be affected.

Fortunately, Anderson et al.'s (2018) method can subsequently also be used to iteratively obtain counterfactual multilateral resistance terms, which yields counterfactual trade outcomes for a given level of production and expenditure (the so-called conditional general equilibrium) for countries directly *and* indirectly affected by the counterfactual policy scenario. Finally, the model also provides the full endowment general equilibrium, which yields counterfactual trade flows, MRTs, production and expenditure (that is welfare).

Data

We draw on two different datasets to collect information on bilateral trade flows. The first dataset is the OECD Trade in Value-Added (TiVA) dataset, December 2016 release. The database covers 63 countries from the OECD, EU28, G20 and countries from Southeast Asia and South America and a Rest-of-the-World (ROW) aggregate. A full list of countries will be provided with the main results, below. The data are available for the period 1995–2011 (annually). This dataset yields two variables of interest on bilateral trade flows, namely the FD_VA series on the value-added content of final demand, by source country and industry (in USD million), and the GX series as gross exports by source country and industry (in USD million). We refer to the former as TiVA-VAX and the latter as TiVA-GX.

The second dataset is based on the World Input-Output Database (WIOD), in particular, a recent release by Los and Timmer (2018). WIOD data cover 43 countries and a ROW aggregate and the period 2000–2014. Los and Timmer (2018) argue that recent studies of supply-chain trade in a gravity framework rely on what they call VAX-C. However, they argue that this measure is not entirely appropriate when considering the effects of bilateral policy measures on bilateral value-added flows. By construction, VAX-C does not accurately indicate value-added trade in bilateral settings and may still contain value-added trade of countries beyond the bilateral pair under consideration. Los and Timmer (2018) address this problem by introducing a novel measure, dubbed VAX-D, which they argue is suitable for bilateral trade flow analyses.

Given the ongoing discussion on the proper construction of suitable measures for bilateral value-added trade, we explore the sensitivity of our findings to by presenting all estimates in terms of TiVA-VAX, WIOD-VAX-C and WIOD-VAX-D.[11]

Los and Timmer (2018) provide a useful illustration, which we repeat here in abbreviated form for the purpose of the present study. Consider a global production chain, in which a good's raw materials originate in country A and sequentially move through the chain as intermediate goods in country B and C, reaching country D for final assembly and country E for consumption. Further assume that countries A through D each contribute 1 unit of value-added. As Table 2 indicates, *bilateral* gross export statistics will count both country A as well as country B's value-added contribution (the so-called problem of double counting). Turning to value-added measures, the measure that has most commonly been used thus far in applied work is VAX-C. Bilateral VAX-C flows between B and E will show that country B indeed provided 1 unit of value-added to the product consumed in E. Yet for policy analyses with the gravity equation, there is a potential problem. For example, analysing the counterfactual effect of an FTA introduced between pair BD needs

Table 2. *Gross versus value-added exports.*

From	B			C		D
To	C	D	E	D	E	E
Gross exports	2	0	0	3	0	4
Domestic value-added for						
... direct use (VAX-D)	1	0	0	1	0	1
... consumption (VAX-C)	0	0	1	0	1	1

Note: Based on Los and Timmer (2018), Table 1.

value-added measures to indicate the value of products exported by B directly used in D's production. Note that VAX-C and VAX-D are identical for flows from the final assembler to consumer. In this situation, what matters for gravity analyses is that VAX avoids the problem of double-counting in gross export statistics.

For the sake of comparability of our results, and following Yotov et al.'s (2016) recommendation to use interval data as opposed to annual data, we retain data for the years 2002, 2005, 2008 and 2011 from both datasets. The selection of these years steers clear of possible concerns pertaining to the structure of the world economy under the "first" and "second" unbundling Baldwin (2006). 2008 data also do not yet reflect the effect of the financial crisis and the Great Trade Collapse.

TiVA-VAX provides both international and intra-national values for trade in value-added. The dataset provided by Los and Timmer (2018) only contains VAX-C and VAX-D values for international flows. Fortunately, we can complement these variables with intranational flows extracted from WIOD (Kaplan et al., 2018). For a detailed discussion of the importance of intra-national trade flows in structural gravity models and the related literature (Baier et al., 2017, 48–49).

Geographic distance and contiguity are from the familiar CEPII GeoDist database Mayer and Zignano (2011). We calculate intranational distances following Anderson and Yotov (2016). Information about countries' participation in FTAs is from Kohl (2014) and the WTO's Regional Trade Agreements Information System. By construction, BRDR is a binary variable which is 0 if the origin and destination country are identical to indicate intra-national trade and 1 otherwise.

Results

Southbound

We first consider the southern leg of the Belt Road Initiative, which is a high-speed railway system stretching from China to Singapore through Laos, Thailand and Malaysia.[12] We consider three possible scenarios in which infrastructural developments allow the geographic distance between these countries to be reduced by 15%, 30% and 50%, respectively.

Figure 1 shows that the gains in trade from the 15% to 50% reduction in distance yields varying degrees of improvement in both gross exports and value-added trade. First, notice the substantial differences in the estimated magnitudes for Singapore's gross exports as opposed to its trade in value-added. Clearly, decreasing trade costs would substantially increase gross trade for Singapore as one of Asia's key trade hubs by 3–15%, depending on the overall decrease in distance. However, most of this trade is simply transit with very little to no value-added activities provided by Singapore. In contrast, the estimated increase in value-added trade is only about 1–3%. Findings for Malaysia relay a qualitatively similar insight that gross trade statistics overstate BRI's effect on participating members' economies when double-counting is unaccounted for. For the remainder of the article, we therefore refrain from using data on gross exports and prefer to shed more light on the performance of value-added trade measures.[13]

In terms of value-added exports, we find that Thailand, Malaysia and Singapore stand to gain more than China in any scenario in which distance is reduced. China would see its trade increase by a rather negligible 0.3–1.3%. Singapore's value-added will rise between 0.6% and 2.9%, Malaysia 1% and 5.1% and Thailand 1.2% and 6.2%. We also find evidence of welfare improvements for these countries, albeit very small (that is, at most 0.63% for Malaysia if distance were to decrease by 50%). Would opting for a BRI-inspired FTA in this region be of some use? Recall that all of these countries are already engaged in the ASEAN FTA, so that a BRI-initiative in southern Asia would have to be related to infrastructural developments.

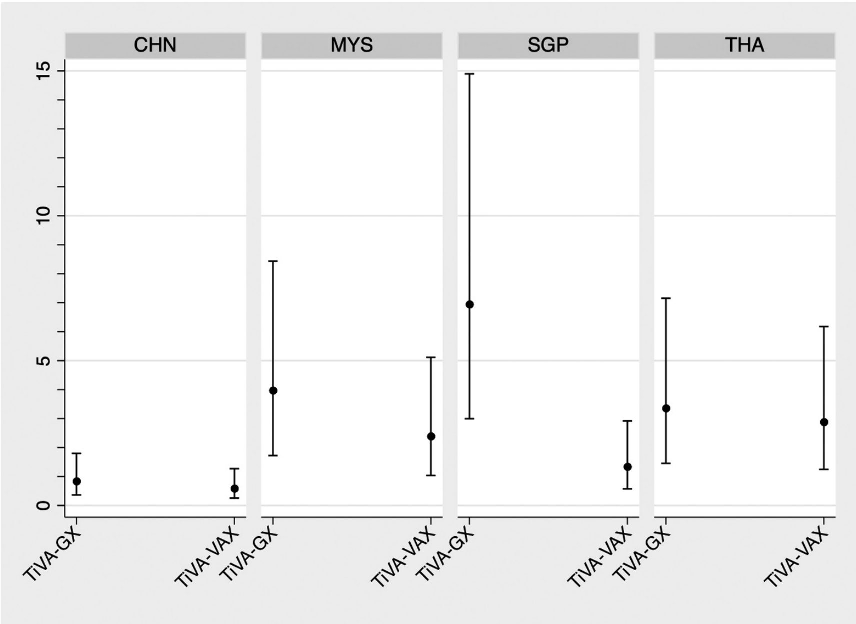

Figure 1. *Full endowment general equilibrium effects on trade, induced by changes in distance along the BRI's southern route through Thailand, Malaysia and Singapore based on TiVA-GX and TiVA-VAX. The lowest (highest) end of the whisker represents the effect of a 15% (50%) reduction in bilateral distance and the dot marks the effect of a 30% reduction.*

Westbound

While China already participates in trade agreements with countries in southern Asia, it does not yet have any trade agreements beyond its WTO commitments with respect to Kazakhstan, Russia or the European Union. Figure 2 provides an overview of the results when the PRC were to invest in distance-decreasing infrastructure improvements to facilitate trade with Russia and the EU.[14] For ease of exposition, we will discuss the EU average, Russia and China, while full country-level information for trade and welfare is provided in Tables A2 and A3, respectively.

The heterogeneous outcomes for the different actors involved are striking. Setting differences between the types of value-added measures aside for the moment, notice that any reduction in distance will always be more beneficial for Chinese and Russian trade than for the EU. In terms of VAX-D estimates, Russian trade is expected to increase by 4–20.7% for a distance reduction of 15–50%, respectively. For China and the EU, these ranges are 3–16.6% and 1–6%, respectively.

A likely explanation for these findings is that while the bulk of the EU's supply-chain trade is intra-EU, rather than with China, Russia and China now gain improved access not only to each other, but to the world's largest market. Translating these findings to changes in welfare, China and the EU would at best gain about 1%, and Russia 3%.

Turning to the difference between TiVA-VAX and WIOD outcomes, the former are somewhat more conservative than WIOD. One possible advantage of TiVA data in this regard is that the OECD separates Chinese processing trade activities from regular production activities, reducing aggregation biases (Koopman et al., 2012). Interestingly, the results with VAX-C and VAX-D are consistently very similar. As discussed above, bilateral VAX-C and VAX-D

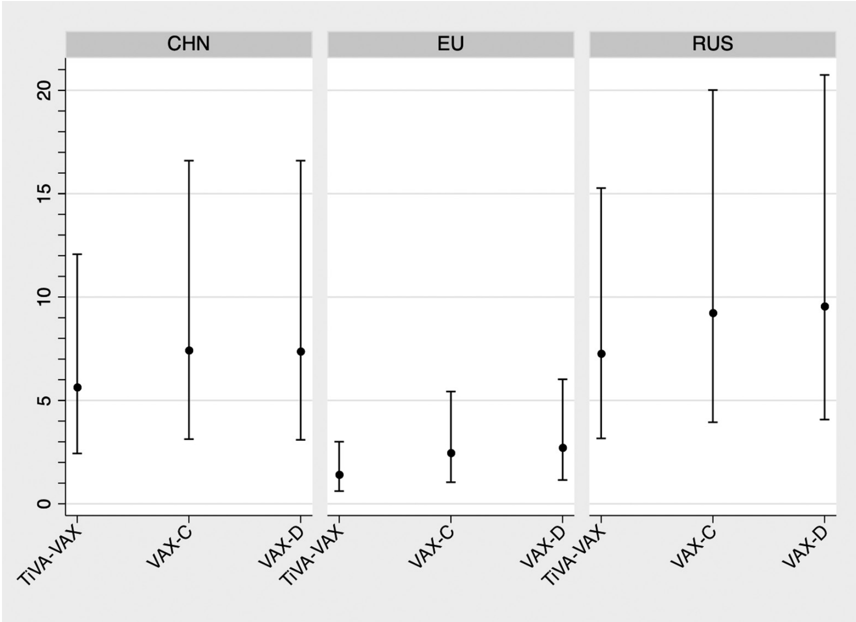

Figure 2. *Full endowment general equilibrium effects on trade, induced by changes in distance along the BRI's western route with Russia and the EU based on TiVA-VAX, VAX-C and VAX-D. The lowest (highest) end of the whisker represents the effect of a 15% (50%) reduction in bilateral distance and the dot marks the effect of a 30% reduction.*

flows will by construction be reasonably comparable if Chinese exports are primarily assembled goods (that is compare flows from country D to E in Table 2).

All the way

We now consider the situation that the BRI succeeds in implementing the key infrastructural developments needed for a cross-continental revival of the Silk Road, stretching from Singapore and Shanghai all the way to Rotterdam. The main results are presented in Figures 3 and 4.[15]

The figures essentially repeat the discussion of the westbound route. Moreover, a quick comparison of the southbound and BRI options reveals a substantial improvement to Southeast Asian nations' gains from BRI—both in terms of trade and welfare—which can largely be ascribed to their improved geographic proximity to the European market. Under the most optimistic scenario, such access bolsters Malaysian trade in general equilibrium by up to 11.7% (compared with 5.1%), Singapore by 6.4% (was 2.9%) and Thailand by 15.1% (was 5.1%). These improvements are also reflected in improvements in these nation's welfare outcomes. Unfortunately, lack of WIOD's coverage of Southeast Asian economies limits our ability to compare results across data sources.

FTAs as alternatives to the BRI

Given the magnitude of our previous outcomes, the gains of BRI are not evenly spread across the geographical landscape of potential future participants. Given these asymmetries, it is not difficult to imagine that the BRI—in terms of infrastructural developments and commitments—might be a bridge too far for all envisioned partner countries.

An alternative strategic goal might therefore be to consider the possibility of a BRI-based FTA, that is signing an FTA between China,

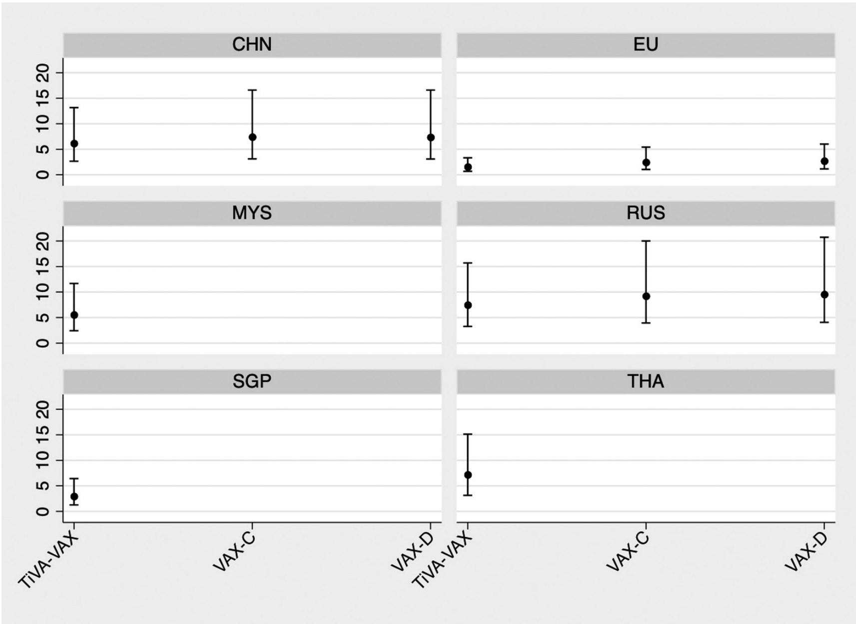

Figure 3. *Full endowment general equilibrium effects on trade, induced by changes in distance along the entire BRI's route including the EU, Russia, Thailand, Malaysia and Singapore based on TiVA-VAX, VAX-C and VAX-D. The lowest (highest) end of the whisker represents the effect of a 15% (50%) reduction in bilateral distance and the dot marks the effect of a 30% reduction.*

Russia and the EU, and China's ASEAN-partners in the southbound leg of the BRI. As discussed previously, infrastructural improvements and tariff reductions both are routes to achieving the same objective: lowering bilateral trade costs.

Indeed, Figure 5 confirms that the trade outcomes for the major countries involved would be positive under a BRI-inspired FTA. Trade would increase for China by 0.5–2.1%, depending on the measure used (see Tables A4 and A5 for detailed trade and welfare estimates, respectively). Russia's expected trade effects are now just a fraction of the infrastructural version, ranging between 0.27 and 0.79%. For the EU, the average gains are a mere 0.1–0.4%. Southeast Asian members included in the BRI can also expect marginally positive effects in trade, while other countries in the region can expect some trade diversion. To the extent that a comparison can be made between results obtained with TiVA and WIOD data, notice that the TiVA estimates are now the least conservative, while the differences between VAX-C and VAX-D remain relatively small.[16]

As a second alternative, China could join the negotiations on TPP to strengthen its Asian-Pacific base and to gain improved market access to both American continents. Yet, our estimates reveal that such an outcome would actually lead to trade diversion for the PRC in the order of magnitude −0.3% to −1.1%, depending on the measure used. As could be expected, the effects of further regional integration will be noticeable for member countries, with no striking trade creation or diversion effects elsewhere. Indeed, Figure 6 shows that the gains of further integration throughout the Pacific region are expected to increase trade for participants such as Australia (0.7–2.9%), Brunei (2.2%), Cambodia and Korea (0.6%), Canada (1.4–4.3%), Indonesia (0.2–1%), India (0.06–0.5%),

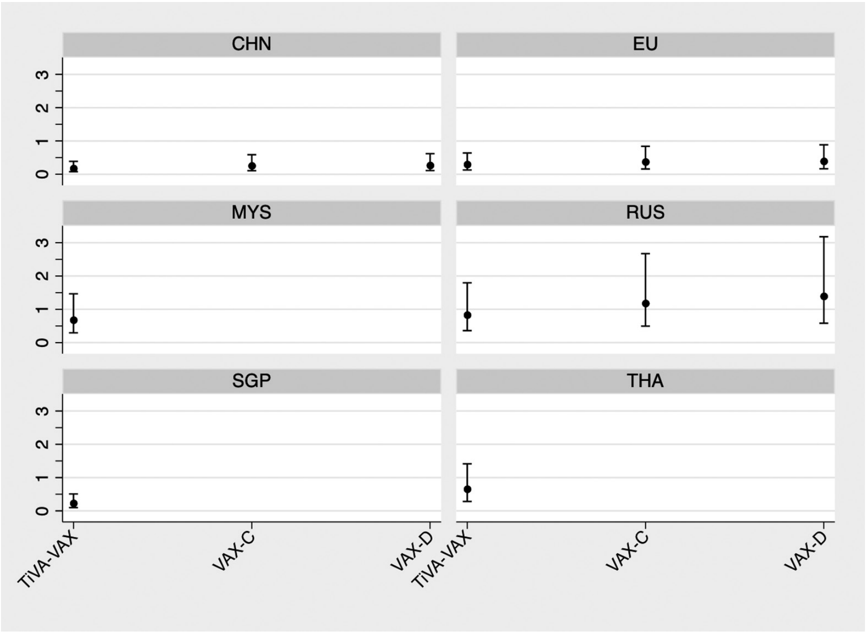

Figure 4. *Full endowment general equilibrium effects on welfare, induced by changes in distance along the entire BRI's route including the EU, Russia, Thailand, Malaysia and Singapore based on TiVA-VAX, VAX-C and VAX-D. The lowest (highest) end of the whisker represents the effect of a 15% (50%) reduction in bilateral distance and the dot marks the effect of the 30% reduction.*

Figure 5. *Full endowment general equilibrium effects for trade (white circles) and welfare (black circles) induced by a BRI-inspired FTA including the EU, Russia, Thailand, Malaysia and Singapore based on TiVA-VAX, VAX-C and VAX-D.*

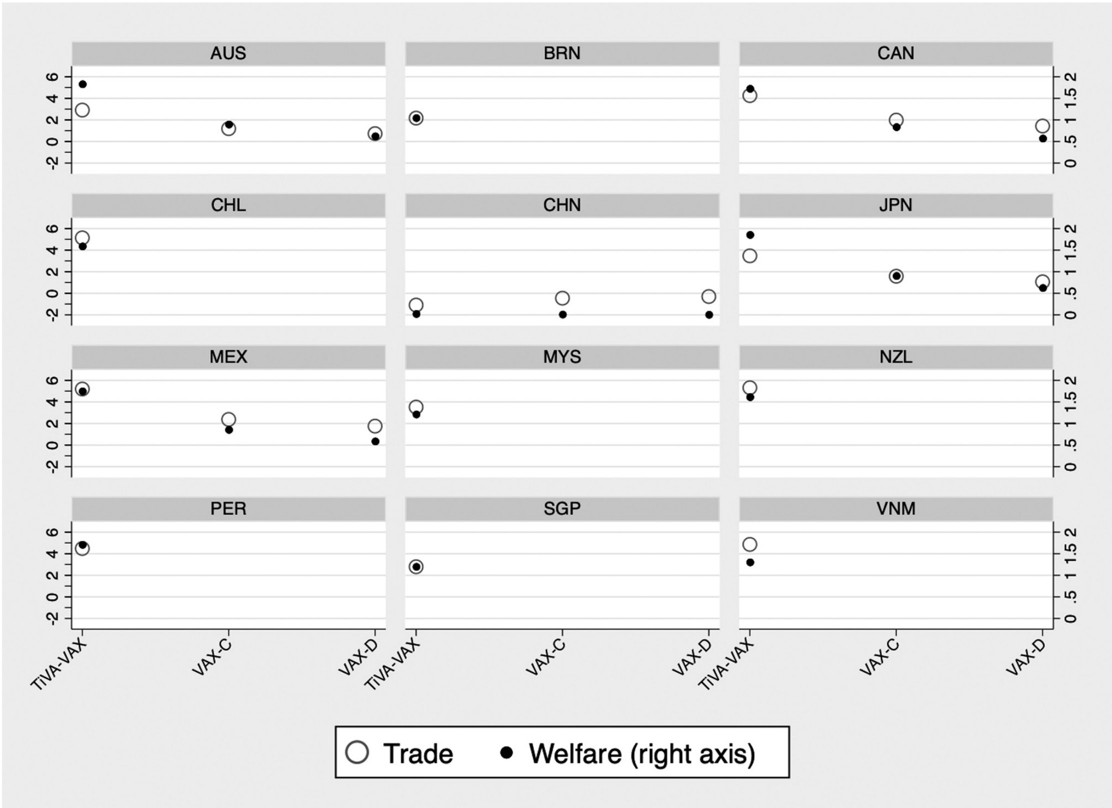

Figure 6. *Full endowment general equilibrium effects on trade (white circles) and welfare (black circles) for TPP based on TiVA-VAX, VAX-C and VAX-D.*

Japan (1.1–3.5%), Malaysia (3.5%), New Zealand (5.3%), Peru (4.5%), Singapore (2.8%) and Vietnam (4.9%). Even despite its withdrawal from the negotiations, the USA could still expect a gain in trade between 0.4% and 1.5%. The welfare effects are smaller yet consistent with this pattern, with several countries gaining between 1% and 2%. Yet, given the anticipated trade diversion for China, TPP does not seem a fruitful avenue for the PRC to pursue.

As a final alternative, the PRC could push for a conclusion on the RCEP negotiations. However, the outcomes presented in Figure 7 are again similar to those of TPP. China faces reduction in trade of –0.2% to –0.5% with more positive gains for member countries. In light of the marginal welfare losses, there also is no obvious incentive for the PRC to consider RCEP a fruitful alternative to pursuing a BRI strategy.

Overall, these results lend support to the view that the PRC stands to gain the most in terms of trade and welfare from pursuing the BRI through infrastructural developments leading to a reduction in trade costs. Such a strategy will yield asymmetric benefits, as improved physical market access to the European market would in particular be beneficial to BRI partners in Southeast Asia and Russia. In contrast, the benefits for EU firms are less pronounced. Yet compared with the gains from economically integrating through the negotiation of FTAs, our results suggest that pursuing a BRI through infrastructural developments aligns most closely with China's economic interests.

Discussion and conclusion

We have analysed how China's Belt and Road Initiative will affect supply-chain trade under a variety of possible scenarios, in which the BRI succeeds establishing either a southbound corridor to Singapore, a westbound corridor to the European Union, or both. Using a structural gravity equation, we obtain novel, general equilibrium effects that shed light on the economic consequences of different parts of the BRI on trade and welfare. Our findings account for different measures of trade in value-added, specifically VAX(-C) as is standard from TiVA and WIOD, along with a novel VAX-D measure on value-added proposed by Los and Timmer (2018). While we do find the expected differences between both major data sources, the differences between VAX-C and VAX-D are, for the purposes of this study, very similar. Given China's prominence as final assembler in the world economy, differences in *bilateral* VAX-C and VAX-D will not yield substantially different outcomes when assessing alternative trade policy outcomes with quantitative trade models.

We hypothesised that BRI could lower trade costs, and thereby stimulate international trade, by either a reduction in participating nations' bilateral geographic distance or by creating a FTA. While it is impossible at the time of writing to determine the precise reduction in transportation costs that a fully implemented BRI would generate, we find

Figure 7. *Full endowment general equilibrium effects on trade (white circles) and welfare (black circles) for RCEP based on TiVA-VAX, VAX-C and VAX-D.*

that even a conservate reduction in distance by 15% would in general yield more favourable gains from trade than the alternative of creating FTAs with countries along the Silk Road. Improved market access to the EU through BRI's infrastructural improvements would especially favour Russia and China, while the EU's gains of any BRI-related reduction of trade costs are relatively small. Combined with the EU's recent scepticism about the BRI—in particular, because of the EU's concern that BRI undermines its own geopolitical interests and disrupts the EU cohesion policy—Eurasian cooperation to bring BRI to fruition does not seem a likely outcome at the time of writing (Heide et al., 2018; Mohan, 2018).[17]

What remains are different fora of trade negotiations currently underway, neither of which our results suggest would undermine China's economic growth prospects in the Asian region. Our findings suggest that a BRI-inspired FTA would be a more suitable alternative in case infrastructural developments do not or cannot materialise. However, our results do not preclude the possibility that the PRC decides to pursue an agreement such as TPP despite the bleak economic forecast for the Chinese economy. After all, TPP might still be attractive from a geopolitical perspective, granting China an opportunity to assert greater influence in both American continents.

Ultimately, any final trade policy outcomes would be subject to a complex function of the political economy forces at play. The precise contents of these agreements will provide more fine-grained information for fruitful analyses of China's envisioned trade policy initiatives to shape the world economy in the coming decades. In the meantime, trade policy analysts can prepare for such analyses by addressing a number of limitations in the current literature.

Absent detailed information on the exact policies contained in the FTAs under consideration, we are not yet able to account for potential differences in trade outcomes that could stem from differences in the design of these particular agreements. The recent literature has acknowledged the importance of the design of trade agreements and how these shape economic outcomes (see, for example Kohl et al., 2016; Zhang and Wu, 2018). Armed with novel refinements to data on the specific contents of individual FTAs, including tariff and non-tariff barriers to trade and investment, future research can provide rich analyses on the potential outcomes of China's forthcoming FTAs.

Finally, distance is assumed to uniformly affect travel times across countries and across all modes of transportation. Future research should provide a more detailed understanding of how distance affects transportation costs and trade across various modes of transportation including road, rail, air, maritime, or any combination of these networks. Policies aimed at reducing trade costs through infrastructural developments may have a differential impact on transport cost reductions by mode of transportation. Moving forward, trade volumes should be distinguished by mode of transportation to determine the extent to which the quantity of trade changes in response to a change in relevant transport costs. While the relevant data are unfortunately not yet systematically available on a global and bilateral scale for a significant number of countries and years, data for the US' trade with the European Union (for example Besedeš and Panini Murshid, 2017) provide a fruitful avenue to pursue this line of inquiry.

Endnotes

[1] See Chen (2018) for an overview of rail routes between China and Europe through Central Asia.

[2] These studies go to great lengths to quantify (the quality of) infrastructure, which in turn alters the bilateral trade cost matrix and affects international trade. Given the uncertainty involving the exact trajectories of the BRI's railways at the time of

writing, we instead take a more general approach by directly modifying the bilateral distance (that is trade cost) matrix, as explained below.

[3] For an insightful discussion of the political economy of regional trade integration in the Asian region, see Devadason (2014, 473–477).

[4] ASEAN+3 is the core group of 10 ASEAN members and China, Japan and South Korea. ASEAN+6 extends this group to include Australia, New Zealand and India.

[5] At the time of writing, President Obama had just started his second term in office and the prospect of a US withdrawal was not anticipated.

[6] Citing available data and interviews, the authors argue that future railroad investments would cut travel time by up to 50%, while Chinese harbours already function at peak efficiency and further investments are unlikely to further speed up processing times. Moreover, BRI is not expected or assumed to increase the carrying capacity or speed of container ships or cargo aircraft. Unfortunately, their trade data do not account for the mode of transportation per trade flow, which subjects their obtained distance elasticities per mode of transportation to significant measurement bias.

[7] Note that our approach differs from Caliendo and Parro (2015), who incorporate detailed input-output linkages into their gravity model. Instead, we directly incorporate measures of trade in value-added as dependent variable, acknowledging that these measures themselves have been constructed based on national input-output tables. For a discussion on the construction of these measures, see Timmer et al. (2015).

[8] When performing the analyses with counterfactual changes in bilateral distance, note that the baseline gravity equation is estimated without pair fixed-effect to obtain a baseline parameter estimate for distance.

[9] Due to the challenges involved in solving the counterfactual model in a panel, we from now on only consider data for 2011, that is the final year of the panel, following Yotov et al. (2016).

[10] Note that the reduction only applies to affected country-pairs for a given policy scenario. The actual distance in kilometres is multiplied by 0.85, 0.7 or 0.5, respectively, before taking logs.

[11] Some country-level estimates are only available based on TiVA, given difference in the databases' country coverage.

[12] Note that Laos is excluded from our analyses, given that it is not represented in either TiVA or WIOD.

[13] For a complete overview of the general equilibrium outcomes for trade and welfare for all countries in the southbound BRI route, see Table A1.

[14] Kazakstan is not covered by either TiVA or WIOD and therefore excluded from this analysis.

[15] For the sake of brevity, we do not present a separate table for this scenario in the Appendix, as the values are effectively the sums of the southbound and westbound scenarios. Complete tables are available from the author upon request.

[16] A theoretical possibility is that the PRC pursues BRI through both infrastructural development and an FTA with all participating nations. For brevity we do not report this situation, but the results are essentially obtained by summing over both these scenarios.

[17] In calculations not reported in this article for the sake of brevity, China and Russia could still push for a shorter corridor without the EU, which would connect China with Russia via Mongolia. However, the gains of this endeavour—absent access to the vast European market—are marginal.

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Appendix

Table A1. *Distance effects of southbound BRI on trade and welfare.*

Country/ΔDistance	Trade effects						Welfare effects					
	TiVA-GX			TiVA-VAX			TiVA-GX			TiVA-VAX		
	–15%	–30%	–50%	–15%	–30%	–50%	–15%	–30%	–50%	–15%	–30%	–50%
CHN	0.36	0.84	1.8	0.26	0.59	1.27	0.01	0.03	0.06	0.01	0.02	0.04
HKG	–0.02	–0.05	–0.1	–0.02	–0.04	–0.08	0.00	0.00	–0.01	0.00	0.00	0.00
IDN	–0.04	–0.09	–0.18	–0.03	–0.06	–0.13	0.00	–0.01	–0.01	0.00	0.00	–0.01
IND	–0.01	–0.03	–0.07	–0.01	–0.03	–0.07	0.00	0.00	–0.01	0.00	0.00	0.00
JPN	–0.02	–0.04	–0.08	–0.01	–0.03	–0.07	0.00	0.00	0.00	0.00	0.00	0.00
KHM	–0.02	–0.04	–0.09	–0.01	–0.03	–0.07	–0.01	–0.03	–0.06	–0.01	–0.02	–0.04
KOR	–0.02	–0.04	–0.08	–0.01	–0.03	–0.06	0.00	0.00	0.00	0.00	0.00	0.00
MYS	1.72	3.98	8.43	1.03	2.39	5.12	0.18	0.41	0.88	0.13	0.29	0.63
NZL	–0.01	–0.03	–0.05	–0.01	–0.02	–0.04	0.00	0.00	–0.01	0.00	0.00	0.00
PHL	–0.02	–0.04	–0.08	–0.02	–0.04	–0.08	0.00	–0.01	–0.01	0.00	0.00	–0.01
ROW	–0.01	–0.02	–0.05	–0.01	–0.02	–0.05	0.00	0.00	0.00	0.00	0.00	0.00
SGP	2.99	6.95	14.9	0.58	1.34	2.92	0.08	0.18	0.39	0.05	0.11	0.23
THA	1.45	3.36	7.15	1.24	2.89	6.18	0.16	0.36	0.79	0.11	0.26	0.57
TWN	–0.02	–0.04	–0.09	–0.01	–0.03	–0.07	0.00	0.00	–0.01	0.00	0.00	0.00
VNM	–0.02	–0.04	–0.09	–0.02	–0.04	–0.08	0.00	–0.01	–0.02	0.00	–0.01	–0.01

Note: Full endowment general equilibrium effects on trade and welfare for TiVA's gross exports and value-added exports in the southbound leg of BRI, selected countries only (estimates for other countries are essentially zero).

Table A2. *Distance effects of westbound BRI on trade.*

Country/ΔDistance	Trade effects								
	TiVA-VAX			VAX-C			VAX-D		
	–15%	–30%	–50%	–15%	–30%	–50%	–15%	–30%	–50%
ARG	–0.05	–0.12	–0.25						
AUS	–0.07	–0.16	–0.35	–0.11	–0.26	–0.57	–0.11	–0.27	–0.59
AUT	0.6	1.39	2.95	1.03	2.44	5.39	1.04	2.47	5.5
BEL	0.46	1.07	2.29	0.68	1.62	3.61	0.74	1.78	3.99
BGR	0.46	1.05	2.22	0.9	2.12	4.61	0.93	2.2	4.82
BRA	–0.07	–0.16	–0.34	–0.11	–0.25	–0.55	–0.11	–0.26	–0.58
BRN	–0.03	–0.07	–0.14						
CAN	–0.05	–0.11	–0.23	–0.07	–0.16	–0.35	–0.07	–0.16	–0.34
CHE	–0.09	–0.2	–0.43	–0.14	–0.33	–0.73	–0.17	–0.41	–0.89
CHL	–0.05	–0.11	–0.24						
CHN	2.43	5.64	12.07	3.13	7.43	16.6	3.09	7.38	16.6
COL	–0.06	–0.13	–0.27						
CRI	–0.05	–0.11	–0.23						
CYP	0.62	1.42	2.99	1.43	3.36	7.36	1.46	3.46	7.62
CZE	0.53	1.23	2.62	0.94	2.22	4.89	1.03	2.45	5.44
DEU	0.58	1.35	2.89	0.86	2.04	4.55	0.86	2.05	4.62
DNK	0.66	1.52	3.23	1.08	2.56	5.66	1.23	2.93	6.51
ESP	0.75	1.73	3.7	1.21	2.87	6.4	1.23	2.93	6.58
EST	0.49	1.13	2.35	0.79	1.85	3.97	0.88	2.06	4.42
EU	0.61	1.42	3	1.05	2.47	5.43	1.15	2.72	6.02
FIN	1	2.3	4.83	1.59	3.73	8.12	1.79	4.2	9.15
FRA	0.68	1.58	3.38	1.05	2.5	5.58	0.99	2.36	5.31
GBR	0.73	1.69	3.62	1.02	2.42	5.39	0.97	2.31	5.18
GRC	0.84	1.94	4.12	1.53	3.62	8.01	1.53	3.63	8.07
HKG	–0.07	–0.16	–0.34						
HRV	–0.08	–0.18	–0.38	–0.15	–0.34	–0.75	–0.17	–0.4	–0.87
HUN	0.52	1.2	2.54	0.92	2.17	4.75	1.12	2.64	5.82
IDN	–0.07	–0.16	–0.33	–0.11	–0.26	–0.58	–0.12	–0.28	–0.61
IND	–0.11	–0.26	–0.55	–0.18	–0.42	–0.92	–0.2	–0.47	–1.03
IRL	0.44	1.01	2.14	0.7	1.65	3.67	1.11	2.63	5.88
ISL	–0.04	–0.09	–0.2						
ISR	–0.1	–0.23	–0.49						
ITA	0.84	1.94	4.13	1.39	3.3	7.36	1.4	3.34	7.48
JPN	–0.1	–0.23	–0.48	–0.16	–0.37	–0.82	–0.17	–0.39	–0.87
KHM	–0.03	–0.07	–0.16						
KOR	–0.08	–0.18	–0.38	–0.11	–0.26	–0.58	–0.18	–0.42	–0.94
LTU	0.67	1.53	3.19	1.16	2.71	5.82	1.34	3.13	6.71
LUX	0.26	0.6	1.27	0.48	1.13	2.51	0.88	2.11	4.72
LVA	0.57	1.31	2.72	0.96	2.24	4.81	1.02	2.39	5.11
MAR	–0.07	–0.16	–0.35						
MEX	–0.06	–0.14	–0.3	–0.1	–0.23	–0.5	–0.11	–0.26	–0.57
MLT	0.45	1.04	2.19	1.1	2.59	5.73	1.7	4.03	8.98
MYS	–0.05	–0.11	–0.23						
NLD	0.47	1.09	2.33	0.66	1.57	3.49	0.8	1.9	4.27
NOR	–0.1	–0.23	–0.49	–0.15	–0.36	–0.8	–0.19	–0.45	–0.98
NZL	–0.05	–0.12	–0.26						

Table A2. *Continued*

Country/ΔDistance	Trade effects								
	TiVA-VAX			VAX-C			VAX-D		
	–15%	–30%	–50%	–15%	–30%	–50%	–15%	–30%	–50%
PER	–0.05	–0.11	–0.23						
PHL	–0.07	–0.16	–0.34						
POL	0.93	2.15	4.54	1.42	3.36	7.39	1.54	3.63	8.01
PRT	0.64	1.48	3.15	1.1	2.61	5.8	1.08	2.57	5.75
ROM	0.74	1.71	3.62	1.3	3.06	6.7	1.3	3.06	6.71
ROW	–0.09	–0.22	–0.46	–0.18	–0.43	–0.96	–0.21	–0.49	–1.07
RUS	3.17	7.27	15.27	3.95	9.24	20.01	4.07	9.56	20.74
SAU	–0.06	–0.13	–0.28						
SGP	–0.02	–0.04	–0.09						
SVK	0.45	1.04	2.2	0.77	1.82	4.01	0.81	1.91	4.23
SVN	0.4	0.93	1.98	0.77	1.81	3.98	0.77	1.82	4.03
SWE	0.8	1.84	3.9	1.38	3.25	7.15	1.48	3.49	7.7
THA	–0.07	–0.16	–0.33						
TUN	–0.06	–0.15	–0.31						
TUR	–0.13	–0.31	–0.65	–0.22	–0.52	–1.16	–0.26	–0.61	–1.33
TWN	–0.06	–0.15	–0.31	–0.1	–0.24	–0.54	–0.18	–0.42	–0.92
USA	–0.1	–0.22	–0.46	–0.14	–0.34	–0.74	–0.14	–0.32	–0.7
VNM	–0.07	–0.15	–0.33						
ZAF	–0.07	–0.15	–0.32						

Note: Full endowment general equilibrium effects on trade for TiVA-VAX, VAX-C and VAX-D in the westbound leg of BRI, all countries.

Table A3. *Distance effects of westbound BRI on welfare.*

Country/ΔDistance	Welfare effects								
	TiVA-VAX			VAX-C			VAX-D		
	–15%	–30%	–50%	–15%	–30%	–50%	–15%	–30%	–50%
ARG	–0.01	–0.01	–0.03						
AUS	0.00	–0.01	–0.02	–0.01	–0.01	–0.03	–0.01	–0.01	–0.03
AUT	0.07	0.17	0.36	0.1	0.24	0.54	0.11	0.25	0.56
BEL	0.05	0.12	0.25	0.06	0.15	0.34	0.06	0.15	0.33
BGR	0.18	0.42	0.89	0.27	0.63	1.41	0.28	0.66	1.47
BRA	0.00	–0.01	–0.02	0.00	–0.01	–0.02	0.00	–0.01	–0.03
BRN	–0.01	–0.03	–0.06						
CAN	0.00	–0.01	–0.02	–0.01	–0.02	–0.04	–0.01	–0.02	–0.04
CHE	–0.01	–0.02	–0.04	–0.01	–0.03	–0.06	–0.01	–0.03	–0.07
CHL	0.00	–0.01	–0.02						
CHN	0.07	0.17	0.36	0.11	0.26	0.59	0.11	0.27	0.62
COL	–0.01	–0.01	–0.03						
CRI	–0.01	–0.02	–0.05						
CYP	0.18	0.42	0.9	0.22	0.53	1.18	0.23	0.54	1.22
CZE	0.1	0.22	0.48	0.14	0.32	0.72	0.14	0.33	0.74
DEU	0.03	0.07	0.15	0.04	0.1	0.23	0.05	0.11	0.25
DNK	0.08	0.18	0.39	0.11	0.26	0.58	0.11	0.27	0.6
ESP	0.04	0.1	0.2	0.06	0.14	0.31	0.06	0.15	0.33
EST	0.31	0.72	1.53	0.41	0.96	2.13	0.44	1.05	2.33
EU	0.12	0.27	0.58	0.16	0.38	0.84	0.17	0.4	0.89
FIN	0.17	0.39	0.83	0.24	0.57	1.27	0.27	0.65	1.45
FRA	0.03	0.08	0.16	0.05	0.12	0.27	0.05	0.13	0.28
GBR	0.03	0.07	0.16	0.04	0.11	0.24	0.05	0.11	0.25
GRC	0.09	0.2	0.43	0.13	0.3	0.67	0.13	0.31	0.71
HKG	0.00	–0.01	–0.02						
HRV	–0.02	–0.06	–0.12	–0.04	–0.09	–0.2	–0.05	–0.11	–0.24
HUN	0.13	0.3	0.63	0.19	0.44	0.99	0.19	0.45	1
IDN	0.00	–0.01	–0.02	–0.01	–0.01	–0.03	–0.01	–0.02	–0.04
IND	–0.01	–0.01	–0.02	–0.01	–0.02	–0.04	–0.01	–0.02	–0.05
IRL	0.08	0.19	0.41	0.11	0.25	0.56	0.1	0.24	0.55
ISL	–0.03	–0.06	–0.13						
ISR	–0.01	–0.02	–0.04						
ITA	0.04	0.08	0.18	0.05	0.12	0.27	0.05	0.13	0.29
JPN	0.00	0.00	–0.01	0.00	–0.01	–0.02	0.00	–0.01	–0.02
KHM	–0.02	–0.04	–0.09						
KOR	0.00	–0.01	–0.02	–0.01	–0.01	–0.03	–0.01	–0.01	–0.03
LTU	0.28	0.64	1.36	0.38	0.9	1.99	0.42	1	2.23
LUX	0.1	0.22	0.47	0.11	0.25	0.57	0.09	0.21	0.47
LVA	0.3	0.7	1.49	0.42	0.99	2.19	0.47	1.12	2.47
MAR	–0.02	–0.04	–0.08						
MEX	0.00	–0.01	–0.02	0.00	–0.01	–0.02	0.00	–0.01	–0.02
MLT	0.16	0.37	0.79	0.15	0.36	0.82	0.12	0.3	0.67
MYS	–0.01	–0.01	–0.03						
NLD	0.04	0.1	0.21	0.05	0.13	0.28	0.05	0.13	0.29
NOR	–0.01	–0.03	–0.07	–0.02	–0.05	–0.11	–0.03	–0.06	–0.13
NZL	–0.01	–0.01	–0.03						
PER	–0.01	–0.02	–0.04						

Table A3. *Continued*

Country/ΔDistance	Welfare effects								
	TiVA-VAX			VAX-C			VAX-D		
	–15%	–30%	–50%	–15%	–30%	–50%	–15%	–30%	–50%
PHL	–0.01	–0.02	–0.03						
POL	0.11	0.25	0.53	0.15	0.35	0.78	0.17	0.39	0.88
PRT	0.07	0.17	0.36	0.09	0.22	0.49	0.09	0.22	0.5
ROM	0.13	0.3	0.65	0.21	0.5	1.11	0.23	0.54	1.2
ROW	–0.01	–0.01	–0.02	–0.01	–0.02	–0.04	–0.01	–0.02	–0.05
RUS	0.35	0.81	1.74	0.5	1.18	2.67	0.58	1.4	3.18
SAU	–0.01	–0.02	–0.04						
SGP	0.00	0.00	–0.01						
SVK	0.13	0.29	0.62	0.17	0.41	0.92	0.17	0.41	0.92
SVN	0.14	0.32	0.69	0.19	0.44	0.99	0.19	0.45	1
SWE	0.1	0.23	0.49	0.16	0.39	0.86	0.18	0.42	0.94
THA	–0.01	–0.01	–0.03						
TUN	–0.02	–0.05	–0.11						
TUR	–0.01	–0.02	–0.05	–0.02	–0.04	–0.1	–0.02	–0.05	–0.12
TWN	0.00	–0.01	–0.02	–0.01	–0.02	–0.04	–0.01	–0.02	–0.04
USA	0.00	0.00	–0.01	0.00	–0.01	–0.01	0.00	–0.01	–0.02
VNM	–0.01	–0.03	–0.05						
ZAF	–0.01	–0.01	–0.03						

Note: Full endowment general equilibrium effects on welfare for TiVA-VAX, VAX-C and VAX-D in the westbound leg of BRI, all countries.

Table A4. *FTA effects on trade.*

Country/FTA	Trade effects								
	TiVA-VAX			VAX-C			VAX-D		
	BRI	TPP	RCEP	BRI	TPP	RCEP	BRI	TPP	RCEP
ARG	–0.03	0.42	0.29						
AUS	–0.07	2.91	2.72	–0.02	1.19	1.1	–0.01	0.73	0.63
AUT	0.36	0.11	0.14	0.15	0.05	0.07	0.06	0.03	0.03
BEL	0.32	0.13	0.19	0.17	0.06	0.07	0.1	0.03	0.04
BGR	0.27	0.1	0.1	0.18	0.04	0.05	0.07	0.01	0.01
BRA	–0.05	0.48	0.47	–0.02	0.16	0.21	–0.01	0.08	0.11
BRN	–0.02	2.17	2.56						
CAN	–0.02	4.26	0.34	–0.01	1.98	0.12	–0.01	1.44	0.07
CHE	–0.05	0.21	0.24	–0.02	0.07	0.07	–0.01	0.04	0.04
CHL	–0.04	5.14	0.53						
CHN	2.13	–1.09	–0.53	0.96	–0.45	–0.24	0.54	–0.3	–0.16
COL	–0.03	0.55	0.28						
CRI	–0.03	0.4	0.27						
CYP	0.29	0.09	0.12	0.2	0.06	0.1	0.09	0.01	0.04
CZE	0.41	0.1	0.13	0.16	0.05	0.06	0.1	0.02	0.03
DEU	0.6	0.2	0.25	0.29	0.08	0.09	0.18	0.04	0.05
DNK	0.49	0.2	0.25	0.19	0.07	0.08	0.11	0.04	0.05
ESP	0.49	0.2	0.21	0.21	0.08	0.08	0.11	0.05	0.03
EST	0.32	0.1	0.12	0.15	0.05	0.06	0.09	0.02	0.02
EU	0.39	0.14	0.18	0.19	0.06	0.07	0.1	0.03	0.03
FIN	0.6	0.21	0.31	0.3	0.08	0.11	0.19	0.05	0.06
FRA	0.64	0.23	0.27	0.27	0.08	0.1	0.15	0.04	0.05
GBR	0.66	0.33	0.4	0.25	0.12	0.13	0.13	0.08	0.07
GRC	0.52	0.15	0.25	0.29	0.07	0.13	0.13	0.01	0.05
HKG	–0.07	0.53	0.74						
HRV	–0.07	0.09	0.1	–0.02	0.04	0.05	–0.02	0.01	0.00
HUN	0.25	0.11	0.14	0.14	0.04	0.06	0.11	0.03	0.04
IDN	–0.07	1	6.54	–0.01	0.31	2.68	–0.01	0.21	1.77
IND	–0.06	0.5	6.81	–0.02	0.14	3.04	–0.01	0.06	1.99
IRL	0.24	0.12	0.15	0.09	0.06	0.06	0.05	0.03	0.03
ISL	–0.05	0.18	0.2						
ISR	–0.04	0.28	0.44						
ITA	0.53	0.2	0.25	0.24	0.08	0.1	0.14	0.04	0.05
JPN	–0.06	3.47	3.56	–0.02	1.58	1.58	–0.01	1.06	1.02
KHM	–0.08	0.63	6.07						
KOR	–0.05	0.67	4.06	–0.02	0.24	1.91	–0.01	0.22	1.55
LTU	0.25	0.09	0.09	0.11	0.03	0.03	0.03	0.00	0.00
LUX	0.14	0.09	0.1	0.09	0.03	0.04	0.04	0.01	0.01
LVA	0.26	0.07	0.11	0.16	0.03	0.05	0.07	0.00	0.00
MAR	–0.06	0.34	0.46						
MEX	–0.02	5.2	0.31	–0.01	2.38	0.12	–0.01	1.76	0.09
MLT	0.3	0.13	0.14	0.15	0.07	0.07	0.08	0.05	0.04
MYS	0.92	3.52	4.09						
NLD	0.39	0.15	0.2	0.2	0.05	0.07	0.13	0.03	0.04
NOR	–0.05	0.2	0.18	–0.02	0.06	0.06	–0.01	0.05	0.03

Table A4. *Continued*

Country/FTA	Trade effects								
	TiVA-VAX			VAX-C			VAX-D		
	BRI	TPP	RCEP	BRI	TPP	RCEP	BRI	TPP	RCEP
NZL	–0.05	5.32	5.32						
PER	–0.04	4.48	0.47						
PHL	–0.07	0.87	6.87						
POL	0.48	0.11	0.16	0.19	0.05	0.07	0.09	0.02	0.03
PRT	0.31	0.13	0.14	0.14	0.05	0.06	0.05	0.02	0.01
ROM	0.34	0.11	0.14	0.21	0.05	0.06	0.1	0.01	0.01
ROW	–0.06	0.5	0.8	–0.03	0.32	0.46	–0.02	0.22	0.33
RUS	0.79	0.2	0.3	0.46	0.1	0.14	0.27	0.04	0.07
SAU	–0.03	0.4	0.7						
SGP	0.97	2.79	3.23						
SVK	0.34	0.07	0.12	0.16	0.04	0.06	0.07	0.01	0.04
SVN	0.26	0.08	0.11	0.14	0.04	0.05	0.06	0.01	0.02
SWE	0.44	0.17	0.22	0.2	0.07	0.08	0.11	0.04	0.04
THA	1.35	0.86	5.53						
TUN	–0.06	0.09	0.14						
TUR	–0.07	0.21	0.34	–0.03	0.07	0.11	–0.02	0.02	0.05
TWN	–0.05	0.69	0.87	–0.02	0.25	0.3	–0.01	0.24	0.28
USA	–0.06	1.54	0.87	–0.02	0.62	0.27	–0.01	0.43	0.14
VNM	–0.06	4.86	5.56						
ZAF	–0.05	0.35	0.57						

Note: Full endowment general equilibrium effects of FTAs on trade based on TiVA-VAX, VAX-C and VAX-D, all countries.

Table A5. *FTA effects on welfare.*

Country/FTA	Welfare effects								
	TiVA-VAX			VAX-C			VAX-D		
	BRI	TPP	RCEP	BRI	TPP	RCEP	BRI	TPP	RCEP
ARG	0.00	–0.02	–0.01						
AUS	0.00	1.84	1.84	0.00	0.9	0.91	0.00	0.63	0.63
AUT	0.03	–0.01	–0.01	0.01	0.00	–0.01	0.00	0.00	0.00
BEL	0.03	–0.01	–0.02	0.02	–0.01	–0.01	0.01	0.00	0.00
BGR	0.03	–0.01	–0.01	0.01	0.00	0.00	0.01	0.00	0.00
BRA	0.00	–0.01	–0.01	0.00	0.00	0.00	0.00	0.00	0.00
BRN	–0.01	1.05	0.94						
CAN	0.00	1.73	–0.02	0.00	0.84	–0.01	0.00	0.58	0.00
CHE	–0.01	–0.02	–0.03	0.00	–0.01	–0.01	0.00	0.00	0.00
CHL	0.00	1.6	–0.04						
CHN	0.07	0.03	0.01	0.04	0.02	0.01	0.02	0.01	0.01
COL	0.00	–0.02	–0.01						
CRI	0.00	–0.04	–0.03						
CYP	0.03	–0.01	–0.01	0.01	0.00	–0.01	0.01	0.00	0.00
CZE	0.05	–0.01	–0.02	0.01	0.00	–0.01	0.01	0.00	0.00
DEU	0.04	–0.02	–0.02	0.02	–0.01	–0.01	0.01	0.00	0.00
DNK	0.04	–0.02	–0.02	0.02	–0.01	–0.01	0.01	0.00	0.00
ESP	0.03	–0.01	–0.01	0.01	0.00	0.00	0.00	0.00	0.00
EST	0.04	–0.01	–0.02	0.02	–0.01	–0.01	0.01	0.00	0.00
EU	0.03	–0.01	–0.02	0.01	0.00	–0.01	0.01	0.00	0.00
FIN	0.04	–0.02	–0.02	0.02	–0.01	–0.01	0.01	0.00	0.00
FRA	0.03	–0.01	–0.01	0.01	0.00	0.00	0.01	0.00	0.00
GBR	0.04	–0.02	–0.02	0.01	–0.01	–0.01	0.01	0.00	0.00
GRC	0.02	–0.01	–0.01	0.01	0.00	0.00	0.00	0.00	0.00
HKG	–0.01	–0.06	–0.08						
HRV	–0.01	–0.01	–0.01	0.00	0.00	0.00	0.00	0.00	0.00
HUN	0.03	–0.02	–0.02	0.01	0.00	–0.01	0.01	0.00	0.00
IDN	0.00	–0.06	1.64	0.00	–0.02	0.82	0.00	–0.01	0.57
IND	0.00	–0.02	1.75	0.00	0.00	0.87	0.00	0.00	0.61
IRL	0.05	–0.03	–0.03	0.02	–0.01	–0.01	0.01	0.00	0.00
ISL	–0.01	–0.02	–0.03						
ISR	0.00	–0.02	–0.03						
ITA	0.03	–0.01	–0.01	0.01	0.00	0.00	0.01	0.00	0.00
JPN	0.00	1.86	1.86	0.00	0.91	0.91	0.00	0.63	0.63
KHM	–0.01	–0.07	1.4						
KOR	0.00	–0.06	1.61	0.00	–0.02	0.81	0.00	–0.02	0.55
LTU	0.02	–0.01	–0.01	0.01	0.00	0.00	0.00	0.00	0.00
LUX	0.05	–0.03	–0.03	0.02	–0.01	–0.01	0.01	0.00	0.00
LVA	0.02	–0.01	–0.01	0.01	0.00	0.00	0.01	0.00	0.00
MAR	0.00	–0.02	–0.03						
MEX	0.00	1.75	–0.01	0.00	0.86	0.00	0.00	0.59	0.00
MLT	0.04	–0.02	–0.02	0.02	–0.01	–0.01	0.01	–0.01	0.00
MYS	0.18	1.22	1.12						
NLD	0.03	–0.01	–0.02	0.02	–0.01	–0.01	0.01	0.00	0.00
NOR	0.00	–0.02	–0.02	0.00	–0.01	–0.01	0.00	0.00	0.00
NZL	0.00	1.62	1.62						

Table A5. *Continued*

Country/FTA	Welfare effects								
	TiVA-VAX			VAX-C			VAX-D		
	BRI	TPP	RCEP	BRI	TPP	RCEP	BRI	TPP	RCEP
PER	0.00	1.72	–0.03						
PHL	0.00	–0.05	1.6						
POL	0.03	–0.01	–0.01	0.01	0.00	0.00	0.01	0.00	0.00
PRT	0.02	–0.01	–0.01	0.01	0.00	0.00	0.00	0.00	0.00
ROM	0.02	–0.01	–0.01	0.01	0.00	0.00	0.01	0.00	0.00
ROW	0.00	–0.04	–0.06	0.00	–0.02	–0.03	0.00	–0.02	–0.02
RUS	0.05	–0.02	–0.02	0.03	–0.01	–0.01	0.02	0.00	0.00
SAU	0.00	–0.07	–0.12						
SGP	0.23	1.2	1.11						
SVK	0.04	–0.01	–0.02	0.01	0.00	–0.01	0.01	0.00	0.00
SVN	0.03	–0.01	–0.01	0.01	0.00	–0.01	0.01	0.00	0.00
SWE	0.04	–0.02	–0.02	0.02	–0.01	–0.01	0.01	0.00	0.00
THA	0.15	–0.1	1.35						
TUN	–0.01	–0.01	–0.01						
TUR	0.00	–0.01	–0.01	0.00	0.00	0.00	0.00	0.00	0.00
TWN	–0.01	–0.09	–0.11	0.00	–0.03	–0.03	0.00	–0.03	–0.03
USA	0.00	–0.04	–0.02	0.00	–0.01	–0.01	0.00	–0.01	0.00
VNM	–0.01	1.31	1.23						
ZAF	0.00	–0.02	–0.04						

Note: Full endowment general equilibrium effects of a BRI-inspired FTA, RCEP and TPP on welfare based on TiVA-VAX, VAX-C and VAX-D, all available countries.